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(54) [Title of Invention] MANUFACTURING METHOD OF LOW IRON LOSS HIGH MAGNETIC FLUX DENSITY UNIDIRECTIONALITY ELECTROMAGNETIC STEEL PLATE

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(57)【要約】

(57) [Abstract]

【課題】　鉄損特性の優れた高磁束密度一方向性電磁鋼板の製造方法を得る。

[Problem]　Manufacturing method of high magnetic flux density unidirectionality electromagnetic steel plate where iron loss characteristic is superior is obtained.

【解決手段】　重量比で、Ｃ：０．０２５～０．０７５％、Ｓｉ：２．５～４．５％、Ｍｎ：０．０５０～０．４５％、Ｓ≦０．０１５％、酸可溶性Ａｌ：０．０１５～０．０４０％、その他、Ｎ、Ｓｎ、Ｃｒ、Ｃｕ等を含有する電磁鋼スラブを１２８０℃以下で加熱後熱延し、最終圧延率を８０％以上とし、ついで脱炭焼鈍、窒化処理、仕上げ焼鈍をする一方向性電磁鋼板の製造において、最終冷延前の鋼板の焼鈍を２段均熱とし、高温側の温度、均熱時間を９５０～１１５０℃、１８０秒以内、低温側の温度、均熱時間を８００～９５０℃、３０～３００秒とし、８００～９５０℃の温度域から３００℃までの平均冷却速度をＲ℃/secで冷却し、最終冷延の複数回

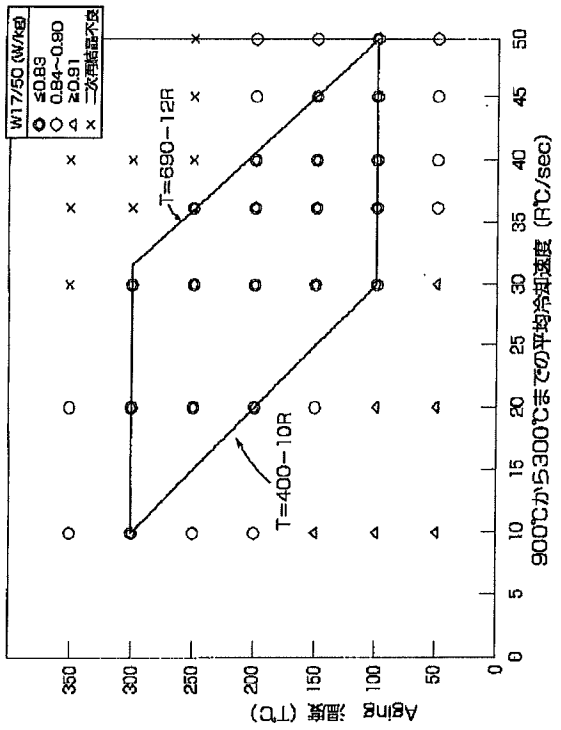
[Means of Solution]　With weight ratio, C: 0.025 to 0.075 %, Si:2.5 to 4.5 %, Mn:0.050 to 0.45 %, S 0.015 %, acid soluble Al :0.015 to 0.040 %, Other things, N, Sn, Cr, electromagnetic steel slab which contains Cu etc after heating is rolled withthe 1280 °C or below, final rolling ratio 80 % or higher to do, Next decarbonizing annealing, nitriding, Producing unidirectionality electromagnetic steel plate which does finished annealing at time of, annealing of steel plate before final rolling 2-stage soaking to do, temperature of high temperature side, soaking time 950 to 1150 °C, Within 180 second, temperature of low temperature side, soaking time is designated asthe 800 to 950 °C and 30 to 300 second, from

のパスの少なくとも１回以上鋼板に１００～３００℃の温度範囲で下記条件を満たすＴ℃で１分以上の時間保持する熱効果を与えることを特徴とする低鉄損高磁束密度一方向性電磁鋼板の製造方法。

temperature region of 800 to 950 °C average cooling rate to the300 °C is cooled with R °C/sec, manufacturing method of low iron loss high magnetic flux density unidirectionality electromagnetic steel platewhich designates that thermal effect which time of 1 min or more iskept with T °C which at least in one time or more steel plate of path of themultiple times of final cold rolling below-mentioned condition is filled upwith temperature range of 100 to 300 °C is given as feature.

４００－１０R≦T≦６９０－１２R

400 - 10R T 690 - 12R



【特許請求の範囲】

【請求項１】　重量比で、Ｃ　：０．０２５～０．０７５%、Ｓｉ：２．５～４．５%、Ｍｎ：０．０５０～０．４５%、Ｓ　≦０．０１５%、酸可溶性Ａｌ：０．０１５～０．０４０%、Ｎ　≦０．０１０%を含有し残部Ｆｅ及び不可避的不純物からなる電磁鋼スラブを１２８０℃以下の温度に加熱した後、熱延し、一回または中間焼鈍を介挿する二回以上の圧延でその最終圧延率を８０%以上とし、ついで脱炭焼鈍、窒化処理、仕上げ焼鈍をする一方向性電磁鋼板の製造において、最終冷延前の鋼板の焼鈍を２段均熱とし、高温側の温度、均熱時間を９５０～１１５０℃、１８０秒以内、低温側の温度、均熱時間を８００～９５０℃、３０～３００秒とし、８００～９５０℃の温度域から３００℃までの平均冷却速度をR℃/secで冷却し、最終冷延の複数回のパスの少なくとも１回以上鋼板に１００～３００℃の温度範囲で下記条

[Claim(s)]

[Claim 1] With weight ratio, C : 0.025 to 0.075 %, Si:2.5 to 4.5 %, Mn :0.050 to 0.45 %, S 0.015 %, acid soluble Al :0.015 to 0.040 %, N 0.010 % was contained and electromagnetic steel slab which consists of remainder Fe andthe unavoidable impurity was heated to temperature of 1280 °C or below rear, It rolls, With rolling of two time or greater which insert one time or intermediate annealing thefinal rolling ratio 80 % or higher to do, Next decarbonizing annealing, nitriding, Producing unidirectionality electromagnetic steel plate which does finished annealing at time of, annealing of steel plate before final rolling 2-stage soaking to do, temperature of high temperature side, soaking time 950 to 1150 °C, Within 180 second, temperature of low temperature side, soaking time is designated asthe 800 to 950 °C and 30 to 300 second, from temperature region of 800 to

件を満たすＴ℃で１分以上の時間保持する熱効果を与えることを特徴とする低鉄損高磁束密度一方向性電磁鋼板の製造方法。

950 °C average cooling rate to the300 °C is cooled with R °C/sec, manufacturing method of low iron loss high magnetic flux density unidirectionality electromagnetic steel platewhich designates that thermal effect which time of 1 min or more iskept with T °C which at least in one time or more steel plate of path of themultiple times of final cold rolling below-mentioned condition is filled upwith temperature range of 100 to 300 °C is given as feature.

４００－１０Ｒ≦Ｔ≦６９０－１２Ｒ

400 - 10R T 690 - 12R

【請求項２】　重量比で、

[Claim2] With weight ratio,

Ｃ　：０．０２５～０．０７５%、

C : 0.025 to 0.075 %,

Ｓｉ：２．５～４．５%、

Si: 2.5 to 4.5 %,

Ｍｎ：０．０５０～０．４５%、

Mn : 0.050 to 0.45 %,

Ｓ　≦０．０１５%、

S 0.015 %,

酸可溶性Ａｌ：０．０１５～０．０４０%、

Acid soluble Al : 0.015 to 0.040 %,

Ｎ　≦０．０１０%、

N 0.010 %,

Ｓｎ：０．０２～０．１５%、

Sn : 0.02 to 0.1 5 %,

Ｃｒ：０．０５～０．３０%を含有し残部Ｆｅ及び不可避的不純物からなる電磁鋼スラブを出発素材とする請求項１記載の方法。

Cr : Method which is stated in Claim 1 which designates electro magnetic steel slabwhich contains 0.05 to 0.30 % and consists of remainder Fe and unavoidable impurity asthe starting material.

【請求項３】　重量比で、

[Claim3] With weight ratio,

Ｃ　：０．０２５～０．０７５%、

C : 0.025 to 0.075 %,

Ｓｉ：２．５～４．５%、

Si: 2.5 to 4.5 %,

Ｍｎ：０．０５０～０．４５%、

Mn : 0.050 to 0.45 %,

Ｓ　≦０．０１５%、

S 0.015 %,

酸可溶性Ａｌ：０．０１５～０．０４０%、

Acid soluble Al : 0.015 to 0.040 %,

Ｎ　≦０．０１０%、

N 0.010 %,

Ｓｎ：０．０２～０．１５%、

Sn : 0.02 to 0.1 5 %,

Ｃｒ：０．０５～０．３０%、

Cr : 0.05 to 0.30 %,

Ｃｕ：０．０３～０．３０%を含有し残部Ｆｅ及び不可避的不純物からなる電磁鋼スラブを出発素材とする請求項１記載の方法。

Cu : Method which is stated in Claim 1 which designates electro magnetic steel slabwhich contains 0.03 to 0.30 % and consists of remainder Fe and unavoidable impurity asthe starting material.

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は鉄損特性の優れた一方向性電磁鋼板の製造方法に関するものである。

【０００２】

【従来の技術】一方向性電磁鋼板は主として変圧器、発電機その他の電気機器の鉄心材として用いられ、それが有する磁気特性として励磁特性と鉄損特性が良好であることの他、良好な被膜を有するものでなければならない。

【０００３】一方向性電磁鋼板は、二次再結晶現象を利用して圧延面に〔１１０〕面、圧延方向に＜００１＞軸を持ついわゆるゴス方位を有する結晶粒を発達させることによって得られる。

【０００４】前記二次再結晶現象は、よく知られているように、仕上げ焼鈍過程で生じるが、二次再結晶の発現を十分なものとするためには、仕上げ焼鈍過程における二次再結晶発現温度域まで一次再結晶粒の成長を抑制するＡＩＮ、ＭｎＳ、ＭｎＳｅ等の微細な析出物、いわゆるインヒビターを鋼中に存在させる必要がある。

【０００５】従って、電磁鋼スラブはインヒビター形成元素、例えばＡｌ、Ｍｎ、Ｓ、Ｓｅ、Ｎ等を完全に固溶させるために、１３５０～１４００℃といった高温に加熱される。そして、電磁鋼スラブ中に完全に固溶せしめられたインヒビター形成元素は、熱延板あるいは最終冷間圧延前の中間板厚の段階で、焼鈍によってＡＩＮ、ＭｎＳ、ＭｎＳｅとして微細に析出せしめられる。

【０００６】この他冶金的には二次再結晶粒を小さくすることにより、磁区細分化を図り鉄損の低減が可能である。この方法には例えば特開昭５０－１６６１０号公報に示される冷間圧延時に熱効果を与える方法、あるいは特開昭５８－２３４１４号公報に示されるような鋼中にＳｎを添加する方法等があり、又プロセス面からは特開平１－２９０７１６号公報に示される如く、冷延鋼板を急速加熱処理し脱炭焼鈍を施す方法が提案されている。これらはいずれも高温スラブ加熱を前提とした製造プロ

[Description of the Invention]

[0001]

[Technological Field of Invention] This invention is something regarding manufacturing method of unidirectionality electromagnetic steel plate where theiron loss characteristic is superior.

[0002]

[Prior Art] Unidirectionality electromagnetic steel sheet is used of transformer and as iron core material of electric generatorother electric equipment mainly, other than thing where excitation characteristic and iron loss characteristicare satisfactory as magnetic property which that has, it must be somethingwhich possesses satisfactory coating.

[0003] { 110 } aspect, is acquired crystal grain which possesses so-calledゴス azimuth which has <001> axis in rolling direction on rollingaspect by advancing unidirectionality electromagnetic steel plate making use of secondary recrystallization phenomenon.

[0004] In order to be known well, it finishes aforementioned secondary recrystallization phenomenon and,occurs with annealing process, but in order to designate revelation of the secondary recrystallization as sufficient ones, AlN, MnS, MnSe or other microscopic precipitate and so-called inhibitorwhich control growth of primary recrystallization grain it is necessary to existin steel to secondary recrystallization manifestation temperature limits which it finishes and in annealing process.

[0005] Therefore, electromagnetic steel slab inhibitor formation element, completely in orderthe solid solution to do, is heated for example Al, Mn, S, Seand N etc to high temperature such as 1350 to 1400 °C. And, in electromagnetic steel slab completely inhibitor formation element which solid solution is done with step of intermediate plate thickness before hot rolled plate or final cold rolling, isprecipitated to fine as AlN, MnS and MnSe withthe annealing.

[0006] In addition magnetic domain fractionize is assured and metallurgy by making secondary recrystallization grainsmall, decrease of iron loss is possible. In this method method of giving thermal effect at time of thecold rolling which is shown in for example Japan Unexamined Patent Publication Showa 50 - 16610 disclosure. Or, as though there is a method etc which adds Sn in kind ofsteel which is shown in Japan Unexamined Patent Publication Showa 58 - 23414 disclosure, in addition fromprocess aspectis shown in Japan Unexamined Patent

セスによるものである。

Publication Hei 1 - 290716 disclosure, cold rolled steel sheet quick heat treatment is done and methodwhich administers decarbonizing annealing is proposed. These in each case are something due to production process which designateshigh temperature slab heating as premise.

【０００７】このような高温スラブ加熱法に対して特開昭６１－６０８９６号公報、特開昭６２－４０３１５号公報等に開示されている技術、即ち二次再結晶に必要なインヒビターは、脱炭焼鈍完了以降から仕上げ焼鈍における二次再結晶発現以前まで造り込むものがある。その手段としては、鋼中にＮを侵入させることによって、インヒビターとして機能する（Ａｌ、Ｓｉ）Ｎを形成させる。

[0007] To before secondary recrystallization revealing which in hibitor which is necessary for thetechnology namely secondary recrystallization which is disclosed in Japan Unexamined Patent Publication Showa 61 - 60896 disclosure and Japan Unexamined Patent Publication Showa 62 - 40 31 5 disclosureetc vis-a-vis this kind of high temperature slab heating method finishes from after decarbonizing annealing completingand in annealing there are some which it makes and are packed. As means, (Al and Si) N which functions by N invading inthe steel, as inhibitor is formed.

【０００８】鋼中にＮを侵入させる手段としては、仕上げ焼鈍昇温過程での雰囲気ガスからのＮの侵入を利用するか、脱炭焼鈍後段領域あるいは脱炭焼鈍完了後のストリップを連続ラインでNH_3等の窒化源となる雰囲気ガスを用いて行う。

[0008] It finishes as means which N invades in steel,utilizes invasion of N from atmosphere gas with annealing temperature-raising step, orit does strip after decarbonizing annealing poststage region or decarbonizing annealing completing making use of theatmosphere gas which becomes NH3 or other nitriding source with continual line.

【０００９】

[0009]

【発明が解決しようとする課題】本発明は、低温スラブ加熱を前提とする特開昭６１－６０８９６号公報に基づくものであるが、このプロセスにおいて重要なことは、脱炭焼鈍板の結晶組織（平均粒径、粒径分布）、集合組織の調整と冷延以降のインヒビターの造り込みである。特に脱炭焼鈍の結晶組織および集合組織は製品の磁気特性に大きな影響を及ぼすことが知られている。

[Problems to be Solved by the Invention] This invention is something which is based on Japan Unexamined Patent Publication Showa 61 - 60896 disclosure which designates low temperature slab heating as premise, but important thing, crystal tissue of the decarbonizing annealing sheet (average particle diameter and particle diameter distribution), is adjustment of gathering tissue and making beingpacked of inhibitor after rolling in this process. As for crystal tissue and gathering tissue of especially decarbonizing annealing it isknown that big influence is exerted on magnetic property of product.

【００１０】結晶組織に影響を与える工程として冷間圧延と脱炭焼鈍がある。もちろん冷間圧延前の焼鈍条件が影響することは言うまでもない。本発明は熱延板焼鈍の冷却条件と冷間圧延時の鋼板温度に着目し、これらの条件と鉄損特性の関係を明らかにして鉄損の低い高磁束密度一方向性電磁鋼板の製造方法を提供するものである。

[0010] There is a cold rolling and a decarbonizing annealing as s tep which produces effect on thecrystal structure. annealing condition before cold rolling influences of course. As for this invention you pay attention to cooling condition of hot rolled plate annealing and thesteel plate temperature at time of cold rolling, it is something which offers manufacturing methodof high magnetic flux density unidirectionality electromagnetic steel sheet where iron loss is low with these condition and therelationship of iron loss characteristic as clear.

【００１１】

[0011]

【課題を解決するための手段】本発明は重量比で、Ｃ：０．０２５～０．０７５%、Ｓｉ：２．５～４．５%、Ｍｎ：０．０５０～０．４５%、Ｓ≦０．０１５%、酸可溶性Ａｌ：０．０１５～０．０４０%、Ｎ≦０．０１０%、必要に応じてＳｎ：０．０２～０．１５%、Ｃｒ

[Means to Solve the Problems] As for this invention with weigh t ratio, C:0.025 to 0.075 %, Si:2.5 to 4.5 %, Mn :0.050 to 0. 45 %, S 0.015 %, acid soluble Al :0.015 to 0.040 %, N 0.010 %, according to need Sn :0.02 to 0.1 5 %, Cr :0.05 to 0.30 %, Cu :0.03 to 0.30 % is contained, electromagnetic

：０．０５～０．３０%、Ｃｕ：０．０３～０．３０%を含有し、残部Ｆｅ及び不可避的不純物からなる電磁鋼スラブを１２８０℃以下の温度に加熱した後、熱延し、一回または中間焼鈍を介挿する二回以上の圧延でその最終圧延率を８０%以上とし、ついで脱炭焼鈍、窒化処理、仕上げ焼鈍をする一方向性電磁鋼板の製造において、最終冷延前の鋼板の焼鈍を２段均熱とし、高温側の温度、均熱時間を９５０～１１５０℃、１８０秒以内、低温側の温度、均熱時間を８００～９５０℃、３０～３００秒とし、８００～９５０℃の温度域から３００℃までの平均冷却速度をＲ℃/secで冷却し、最終冷延の複数回のパスの少なくとも１回以上鋼板に１００～３００℃の温度範囲で下記条件を満たすＴ℃で１分以上の時間保持する熱効果を与えることを特徴とする低鉄損高磁束密度一方向性電磁鋼板の製造方法にある。

steel slab which consists of remainder Fe and unavoidable impurity was heated to thetemperature of 1280 °C or below rear, It rolls, With rolling of two time or greater which insert one time or intermediate annealing thefinal rolling ratio 80 % or higher to do, Next decarbonizing annealing , nitriding , Producing unidirectionality electromagnetic steel plate which does finished annealing at time of, annealing of steel plate before final rolling 2-stage soaking to do, temperature of high temperature side, soaking time 950 to 1150 °C , Within of 180 second, temperature of low temperature side, soaking time is designated as 800 to 950 °C and the30 to 300 second, from temperature region of 800 to 950 °C average cooling rate to 300 °C is cooledwith R °C/sec, there is a manufacturing method of low iron loss high magnetic flux density unidirectionality electromagnetic steel plate whichdesignates that thermal effect which time of 1 min or more is keptwith T °C which at least in one time or more steel plate of path of multiple timesof final cold rolling below-mentioned condition is filled up with thetemperature range of 100 to 300 °C is given as feature.

４００－１０Ｒ≦Ｔ≦６９０－１２Ｒ

400 - 10R T 690 - 12R

【００１２】以下本発明を詳細に説明する。本発明において、出発材料とするスラブの成分組成の限定理由は以下の通りである。Ｃはその含有量が０．０２５%未満では、高磁束密度が安定して得られ難い。一方、０．０７５%を超えて多くなりすぎると、脱炭焼鈍時間が長くなり生産性を損なう。Ｓｉは含有量が２．５%未満になると低鉄損の製品が得られ難く、４．５%を超えると冷間圧延時に、割れ、破断が多発し安定した冷間圧延作業を不可能にする。

[0012] Below this invention is explained in detail. Regarding to this invention, limiting factor of component composition of slab which itmakes starting material is as follows. C is difficult to be acquired content under 0.025 %, thehigh magnetic flux density stabilizing. On one hand, exceeding 0.075 %, when it becomes too many, decarbonizing annealing timebecomes long and impairs productivity. When as for Si when content is under 2.5 %, product ofthe low iron loss is difficult to be acquired, 4.5 % exceeds, at timeof cold rolling, it cracks, cold rolling work breaking occurring frequentlyand stabilizing is designated as impossible.

【００１３】本発明の成分系における特徴の１つは、Ｓを０．０１５%以下、好ましくは０．０１０%以下とする点にある。公知の技術、例えば特公昭４０－１５６４４号公報あるいは特公昭４７－２５２５０号公報に開示されている技術においては、Ｓは二次再結晶を発現させるのに必要な析出物の一つであるＭｎＳの形成元素として必須であった。しかしながら、インヒビターとして（ＡｌＳｉ）Ｎを用いる本発明においては、ＭｎＳは特に必要としない。むしろ、ＭｎＳが増加することは一次再結晶粒径調整を困難にし、高磁束密度鋼板を得難くする。

[0013] As for one of feature in component system of this inve ntion, Sthere is a point which is made 0.015 % or lower and preferably 0.010 % or lower. Was necessary as formation element of MnS which is a one ofthe precipitate which is necessary in order to reveal secondary recrystallization regardingthe technology which is disclosed in known technology , for example Japan Examined Patent Publication Sho 40 - 15644 disclosure or Japan Examined Patent Publication Sho 47 - 25250 disclosure, theS. But, regarding to this invention which uses (Al and Si) N as inhibitor, the MnS especially does not need. it makes primary recrystallization grain size adjustment difficult, makes high magnetic flux density steel plate rare thatrather, MnS increases.

【００１４】ＡｌはＮと結合してＡｌＮを形成するが、本発明においては後工程、即ち、一次再結晶完了鋼を窒化することにより（ＡｌＳｉ）Ｎを形成せしめること

[0014] Al connecting with N, forms AlN, but regarding tothe t his invention, because it makes that it forms (Al and Si) N postprocessing ,namely, by nitriding doing primary

を必須としているから、フリーのＡｌが一定量以上必要である。そのため酸可溶性Ａｌとして０．０１５～０．０４０%添加する。

recrystallization completion steel necessary, theAl of free is constant amount or more necessary. Because of that 0.015 to 0.040 % it adds as acid soluble Al.

【００１５】Ｎは０．０１０%以下にする必要がある。これを超えるとブリスターと呼ばれる鋼板表面の膨れが発生する。下限は、０．００２０%程度がよい。Ｍｎはその含有量が少なすぎると二次再結晶の発達が悪くなり、一方多すぎると磁束密度鋼板が得られ難くなる。適正な含有量は０．０５０～０．４５%である。

[0015] As for N it is necessary to make 0.010 % or lower. When it exceeds this, swelling of steel plate surface which is called blisteroccurs. As for lower limit, 0.0020 % is good. When as for Mn when content is too little, advancement of thesecondary recrystallization becomes bad, is many on one hand magnetic flux density steel plate becomes difficult tobe acquired. proper content is 0.050 to 0.45 %.

【００１６】ＳｎとＣｒは複合添加で仕上げ焼鈍時の被膜形成を安定化すると同時にＳｎは脱炭焼鈍後の一次再結晶集合組織を改善し、ひいては二次再結晶粒を小粒化し、被膜の安定化と相俟って鉄損改善に効果が大きい。Ｓｎの適量は０．０２～０．１５%であり、これより少ないと効果が弱く、一方多いと窒化が困難になり二次再結晶粒が発達しなくなる。Ｃｒの適量は０．０４～０．３０%が良い。Ｃｕは高磁束密度鋼板を得るうえで効果がありその適量は０．０３～０．３０%の範囲である。なお、微量のＰ、Ｔｉを鋼中に含有せしめることは、本発明の主旨を損なうものではない。

[0016] When it finishes Sn and Cr with composite addition and coating formationat time of annealing is stabilized Sn improves primary recrystallizationgathering structure after decarbonizing annealing simultaneously, to small grain convertsthe consequently secondary recrystallization grain, goes hand in hand with stabilization of coatingand effect is large to iron loss improvement. When suitable amount of Sn is 0.02 to 0.1 5 %, it is less than this, effectbecomes weak, when it is many on one hand, nitriding difficult and thesecondary recrystallization grain stops advancing. suitable amount of Cr 0.04 to 0.30 % is good. As for Cu when obtaining high magnetic flux density steel sheet, there is an effect andthe suitable amount is range of 0.03 to 0. 30 %. Furthermore , P of trace amount, fact that Tiis contained in steel is not something which impairs gist ofthe this invention.

【００１７】次に本発明の製造プロセスを説明する。電磁鋼スラブは、転炉あるいは電気炉などの溶解炉で鋼を溶製し、必要に応じて真空脱ガス処理し、しかる後熱間圧延に先立つスラブ加熱が成される。本発明のプロセスにおいては、スラブの加熱温度は１２８０℃以下の低いものとして加熱エネルギーの消費量を少なくするとともに、鋼中のＡｌＮを完全に固溶させずに不完全固溶状態とする。このスラブを熱延して所定の厚みの熱延板を造る。

[0017] Production process of this invention is explained next. electromagnetic steel slab 溶 make does steel with rotary furnace, or electric furnace or other melting furnace the according to need vacuum degassing does, after that slab heating which precedes thehot rolling is formed. Regarding process of this invention, heating temperature of slab as itdecreases consumed amount of heating energy as 1280 °C or below is low, solid solution without doing AlN in steel completely, makes imperfectsolid solution state. Rolling this slab, it makes hot rolled plate of specified thickness.

【００１８】次に、本発明の特徴である熱延板焼鈍条件と冷延条件について説明する。Ｃ：０．０５４%、Ｓｉ：３．２５%、Ｍｎ：０．１０%、Ｐ：０．０２%、Ｓ：０．００８%、酸可溶性Ａｌ：０．０３０%、Ｓｎ：０．０６%、Ｃｒ：０．１２%、Ｎ：０．００７８%を含むインゴットを１１５０℃に加熱した後熱延し２．３mmの熱延板を造った。次いでこの熱延板を表１の条件で焼鈍し冷却した。

[0018] Next, you explain concerning hot rolled plate annealing condition and cold rolling conditionwhich are a feature of this invention. After heating ingot which includes C:0.054 % , Si:3. 25 % , the Mn : 0.1 0 % , P:0.02 % , S:0.008 % , acid soluble Al :0.030 % , Sn :0.06 % , Cr : 0.1 2 % and theN:0.0078 % to 1150 °C it rolled and made hot rolled plate of 2.3 mm. Next, annealing it did this hot rolled plate with condition of Table 1 andcooled.

【００１９】

[0019]

【表１】

[Table 1]

焼鈍条件	冷却条件（900~300℃までの平均冷却速度 ℃/sec）
1120℃×30sec + 900℃×120sec	① 10
	② 20
	③ 30
	④ 36
	⑤ 40
	⑥ 45
	⑦ 50

【００２０】この後酸洗し板厚０．２３mmまで冷延した。この冷延の途中板厚で５０～３５０℃の温度範囲で５分保持するＡｇｉｎｇ処理をした。この条件を表２に示す。

[0020] Acid wash after this it did and rolled to plate thickness 0. 23 mm. Road middle plate of this cold rolling being thick, 5 min it did theAging treatment which is kept with temperature range of 50 to 350 °C. This condition is shown in Table 2.

【００２１】

[0021]

【表２】

[Table 2]

出発板厚（mm）	Ａｇｉｎｇ板厚（mm）	Ａｇｉｎｇ温度（℃）
2.3	1.6、1.2、0.8、0.6	50、100、150、200、250、300、350

（4種のＡｇｉｎｇ板厚それぞれで7種のＡｇｉｎｇ温度を実現）

【００２２】次いで脱炭焼鈍を８３５℃の温度でN_2：２５%、H_2：７５%、露点６５℃の雰囲気中で行った。次いで７５０℃×３０secの窒化処理をN_2、H_2、NH_3の混合ガス中で行い窒化後のN_2量をほぼ２００ppmに調整した。この後ＭｇＯとＴｉO_2を主成分とする焼鈍分離材を塗布し、１２００℃×２０時間の仕上げ焼鈍を行った。この後無水クロム酸、リン酸アルミニウムを主成分とする張力コーティングを施した。熱延板焼鈍後の冷却条件（R℃/sec）－冷延時のＡｇｉｎｇ温度（T℃）－鉄損特性の関係を図１に示す。

[0022] Decarbonizing annealing with temperature of 835 °C w as done next in atmosphere ofthe N2 :25 %, H2 :75 % and dew point 65 °C. Next, nitriding of 750 °C X 30 s was done in mixed gas of N2, theH2 and NH3 and N2 quantity after nitriding was almostadjusted 200 ppm. MgO after this and annealing separating material which designates Ti O2 as themain component were applied, finished annealing of 1200 °C X 2 0 hour was done. chromic anhydride after this, tension coating which designates aluminum phosphate as themain component was administered. Relationship of Aging temperature (T °C) - iron loss characteristic at time of cooling condition (R °C/sec) - cold rolling after the hot rolled plate annealing is shown in Figure 1.

【００２３】この図から４００－１０R≦T≦６９０－１２Rの範囲で非常に優れた低鉄損材が得られることが分かる。熱延板焼鈍の高温側の温度は９５０℃～１１５０℃の範囲とする。この温度より低くても高くても一次再結晶粒の粒径成長が困難になり高B_8特性が得られ難い。この焼鈍時間は１８０秒以内とする。この時間を超しても特別の効果は認められない。

[0023] It understands that low iron loss material which from thi s figure issuperior very in range of 400 - 10R T 690 - 12R is acquired. temperature of high temperature side of hot rolled plate annealing makes range of 950 °C to 1150 °C. Being lower than this temperature, being high, particle diameter growth of primary recrystallizationgrain becomes difficult and high B8 characteristic is difficult to beacquired. This annealing time makes within 180 second. Crossing over this time, special effect is not recognized.

【００２４】低温側の温度は８００～９５０℃の範囲と

[0024] Temperature of low temperature side makes range of 80

する。この温度域がＡｌＮ析出を促進させ一次再結晶粒の粒径調整を容易にさせる他、僅かなγ相を残存させて、この後の急冷によりｈａｒｄ相を形成させ適正な一次再結晶集合組織を得る。焼鈍時間は３０～３００秒がよい。

0 to 950 °C. This temperature region remaining promoting AlN precipitation besides grain size adjustmentof primary recrystallization grain is made easy, little phase, forming ha rdphase with quench after this, you obtain proper primary recrystallization gathering structure. annealing time 30 to 300 second is good.

【００２５】冷却規制温度下限を３００℃とした理由は、急冷によって材質硬度に十分影響を与える温度であるからである。勿論この温度以下も急冷することが好ましい。冷延途中段階のＡｇｉｎｇ温度は１００～３００℃で鉄損改善の効果が大きい。

[0025] Because reason which designates cooling regulation temp erature lower limit asthe 300 °C is temperature which produces fully effect on material hardness withthe quench. It is desirable also for this temperature or lower to do quench of course. Aging temperature of cold rolling middle stage effect of iron loss improvement islarge with 100 to 300 °C.

【００２６】Ａｇｉｎｇ時間は１分以上であれば効果がでるが、好ましくは５分程度が良い。これより長くなっても効果は十分ある。なお工業的にはリバース圧延機による高温圧延域あるいは加熱装置設置により対応できる。本発明においては優れた磁気特性を得る上で、脱炭焼鈍後の一次再結晶粒径とその集合組織の調整が重要である。適正な一次再結晶粒径は１５μｍ以上通常２０～２６μｍと高温スラブ加熱材の１０μｍ程度に比べて大きい。

[0026] Aging time if it is a 1 min or more, effect is produced, b ut preferably 5 min extent isgood. Becoming longer than this, as for effect there is a fully. Furthermore in industrially it can correspond with high temperature rolling limitsor heater installation with reverse roll. Regarding to this invention, when obtaining magnetic property which is superior,the primary recrystallization particle diameter after decarbonizing annealing and adjustment of gathering structure areimportant. proper primary recrystallization particle diameter is large 15 mor greater usually in comparison with 10 mextent ofthe 20 to 26 m and high temperature slab heater.

【００２７】一般に集合組織の面からは粒径が大きくなることは好ましくない。このため、より厳密な集合組織調整が必要となってくる。本発明の冷延前の鋼板の冷却速度と冷延時のＡｇｉｎｇの組み合わせは将にこの冷延集合組織を適正化し好ましい一次再結晶集合組織を得ているものと考えられる。冷間圧延率は高いB_8値を得るために８０%以上とする。

[0027] Generally as for particle diameter becoming large it is no t desirable from theaspect of gathering tissue. Because of this, precise gathering tissue adjustment becomes morenecessary. cooling rate of steel plate before rolling this invention and combination of theAging when rolling optimizing do this cold rolling gathering tissue inthe military officer and are thought thing which obtains thedesirable primary recrystallization gathering tissue. cold rolling ratio makes 80 % or higher in order to obtain high B8 value.

【００２８】脱炭焼鈍は脱炭を行う他に、一次再結晶組織の調整及び被膜形成に必要な酸化層を形成させる役割がある。これは通常８００～９００℃の温度域で湿水素、窒素ガス中で行う。次に窒化処理について述べる。窒化処理は通常脱炭焼鈍後に６５０～８５０℃の温度域でストリップを走行せしめる状態下で行う。

[0028] As for decarbonizing annealing besides decarbonizing is d one, there is a role whichforms oxidized layer which is necessary for adjustment and coating formation ofthe primary recrystallization structure. With temperature region of 800 to 900 °C moisture hydrogen , it does this usuallyin nitrogen gas. Next you express concerning nitriding. It does nitriding under state which usually after decarbonizing annealing thestrip runs with temperature region of 650 to 850 °C.

【００２９】雰囲気ガスは特にこだわらないが、一般に水素ガス、窒素ガス、アンモニアガスの混合ガスを用いる。この後、ＭｇＯ、TiO_2を主成分とするスラリーを塗布し、１１００℃以上の温度で仕上げ焼鈍を公知の方法で行う。

[0029] As for atmosphere gas especially you do not adhere. mi xed gas of hydrogen gas , nitrogen gas and ammonia gas is used generally. After this, it applies slurry which designates MgO and theTi O2 as main component, finishes with temperature of 110 0 °C or higher and does theannealing with known method.

【００３０】

[0030]

【実施例】

[実施例１] Ｃ：０．０５８%、Ｓｉ：３．４５%、Ｍｎ：０．１０%、Ｓ：０．００７%、酸可溶性Ａｌ：０．０２７%、Ｓｎ：０．０５%、Ｃｒ：０．１２%、Ｎ：０．００８０%を含むスラブを１１５０℃に加熱した後熱延し２．６mmの熱延板を造った。

【００３１】次いで熱延板焼鈍を１０８０℃×３０sec＋８５０℃×２min の焼鈍をした後、８５０℃～３００℃までの冷却速度を１０℃/secと、４０℃/secとして室温まで冷却した。この後酸洗し０．３０mmまで冷延した。この冷延の途中板厚段階において表３のようなＡｇｉｎｇ処理を行った。

【００３２】

【表３】

出発板厚 (mm)	Ａｇｉｎｇ板厚 (mm)	Ａｇｉｎｇ条件	
		温度 (℃)	時間 (分)
2．6	1.6、1.0、0.6	① 200	0．5
		② 200	3．0

【００３３】次いで脱炭焼鈍を８３０℃の温度でN_2：２５%、H_2：７５%、露点６５℃の雰囲気中で行った。次いで７５０℃×３０秒の窒化処理をN_2、H_2、NH_3の混合ガス中で行い、窒化後のN_2量をほぼ２００ppm に調整した。この後ＭｇＯとTiO_2を主成分とする焼鈍分離剤を塗布し、１２００℃×２０時間の仕上げ焼鈍を行った。この後水洗し、無水クロム酸、リン酸アルミニウムを主成分とする張力コーティングを施した。磁気特性を表４に示す。本発明の範囲で非常に優れた鉄損値を示している。

【００３４】

【表４】

冷却条件 (℃/sec)	Ａｇｉｎｇ条件			
	200℃×0．5分		200℃×3分	
	B_8	$W_{17/50}$	B_8	$W_{17/50}$
10	1．92	1．03	1．92	1．00
40	1．93	1．00	1．93	0．93

【００３５】

【発明の効果】本発明のの低温スラブ加熱法により、磁気特性の優れた一方向性電磁鋼板を得ることができる。

[Working Example(s)]

[Working Example 1] C: 0.058 % and Si: 3.45 % and Mn : 0.10 % and S: After heating slab which includes 0.007 %, acid soluble Al :0.027 %, the Sn :0.05 %, Cr : 0.12 % and N:0.0080 % to 1150 °C it rolled and made thehot rolled plate of 2.6 mm.

[0031] Next hot rolled plate annealing after doing annealing of 1080 °C X 30 s +850 °C X 2 min , was cooled to theroom temperature cooling rate to 850 °C to 300 °C as 10 °C/sec and 40 °C/sec. acid wash after this it did and rolled to 0.30 mm. Aging treatment like Table 3 in road middle plate heavy filling bar floor of thiscold rolling was done.

[0032]

[Table 3]

[0033] Decarbonizing annealing with temperature of 830 °C was done next in atmosphere ofthe N_2 :25 %, H_2 :75 % and dew point 65 °C. Next, nitriding of 750 °C X 30 second was done in mixed gas of N_2, theH_2 and NH_3, N_2 quantity after nitriding was almostadjusted 200 ppm . MgO after this and annealing fractionating agent which designates TiO_2 as themain component were applied, finished annealing of 1200 °C X 20 hour was done. water wash after this it did, it administered tension coating whichdesignates chromic anhydride and aluminum phosphate as main component. magnetic property is shown in Table 4. iron loss value which is superior very in range of this invention has beenshown.

[0034]

[Table 4]

[0035]

[Effects of the Invention] With low temperature slab heating method this invention, unidirectionality electromagnetic steel

plate where magnetic property is superior can beacquired.

【図面の簡単な説明】

[Brief Explanation of the Drawing(s)]

【図１】Ａｇｉｎｇ温度と熱延板焼鈍の冷速と磁気特性の関係を示す図表である。

[Figure 1] It is a cold speed of Aging temperature and hot rolled plate annealing and a diagram whichshows relationship of magnetic property.

【図１】

[Figure 1]